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The Cyanidation of High Grade Gold and Silver Concentrate

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The cyanidation of high grade gold and silver concentrate is a subject that has lately been attracting the attention of metallurgists in different parts of the world,and offers an interesting field for investigation and research. The inducements are especially strong in districts at long distances from the smelter,and where high freight rates and excessive treatment charges obtain.

It seems to be generally accepted that for the successful cyanidation of concentrate,fine crushing and longer time are necessary,and that there is a much larger consumption of cyanide than when treating low grade ores.Each of these factors tends toward increased cost of the process.The time can sometimes be materially shortened by the judicious use of lead and mercury salts (which in itself may prove expensive) but the additional cost due to fine crushing and increased consumption of cyanide seems to be inevitable,though not necessarily a serious item of expense.

Too much emphasis cannot be laid upon the fact that the physical and chemical properties of an ore very largely affect the ultimate chances of successful cyanidation,and each ore must be regarded as a separate and distinct problem in itself.No hard and fast rules can be laid down as to the behaviour of certain ore bearing minerals in the process.

The following experiments are only of very limted extent and very little serious work could be attempted when so little time was available.

Four different kinds of ore were submitted for investigation as follows:-

No 1. was an oxidised sulphide ore carrying a large amount of free milling gold, and considerable silver. This ore also contained about 8% of metallic iron particles, the coarsest of which were removed by screening.

All assays are reported in grammes per metric ton.

This ore showed that it was not adapted to economical treatment by cyanidation until the coarse gold had been previously removed by amalgamation. After a treatment of five days, the gold extraction by cyanide was only about 10%.

The presence of iron metallics was answerable for an increased consumption of cyanide as shewn by the following experiment in which one sample of ore was freed from iron, another treated with its iron contents, and a third sample consisted of iron metallics alone. Although there is a large consumption of KCN, this was not the cause of non-extraction in subsequent experiments, as the cyanide solution was then kept up to 0.8% strength.

Table No 1.

The effect of iron metallics on KCN.

	0 Days	1 Day	2 Days	3 Days.
Iron metallics	0.6	0.21	0.18	0.08
Metallics and ore	0.6	0.30	0.22	0.16
Ore alone	0.6	0.43	0.38	0.21

The above table shews the decrease of strength of KCN due to metallic iron.

The formation of alkaline sulphides,when in contact with the solution,probably contributed a great retarding influence upon the extraction,and in order to eliminate this, lead salts in sufficient quantity to ensure complete reaction, were introduced in the form of oxide,carbonate,and acetate.

The time available being limited,the experiment was not carried through to ascertain the maximum extraction obtainable by these salts,but only to find out the comparative benefit.It was found that these accelerators aided extraction to a considerable extent,PbO showing itself to be the most efficient in this case. $HgCl_2$ of which much has been written lately,was also tried,but with indifferent success.

The results of the experiments on the raw ore No 1 are tabulated on the next page.The ore assayed 2282 Au,and 5960 Ag per metric ton,at the commencement of the experiment.

The time was kept constant - fifty hours.

PRELIMINARY RUN FOR BEST MESH AND STRENGTH OF CYANIDE SOLUTION.

Table No 5.

	% Strength at start	% Strength at end	Assay at end Au	Assay at end Ag	Extraction % Au	Extraction % Ag
40 mesh	0.1	0.005	2280	5770	nil	3.18
"	0.3	0.106	2280	5750	nil	3.52
"	0.6	0.285	2117	5480	7.36	6.36
100 mesh	0.1	0.003	2142	5900	6.14	1.00
"	0.3	0.074	2078	5100	8.94.	14.00
"	0.6	0.215	1962	5670	14.00	10.00
150 mesh	0.1	0.0095	2165	5947	5.30	nil
"	0.3	0.090	2104	5800	6.91	9.70
"	0.6	0.330	2154	5480	5.62	8.77
"	1.2	0.720	2134	5660	6.50	5.02

USING CONSTANT STRENGTH (0.6%) AND MESH FOUND IN EXP.6 WITH VARYING TIME.

	Hrs	Assay at end Au	Assay at end Ag	Extraction %Au	Extraction %Ag
100 mesh	72	2050	4220	10.3	17.5
"	96	2046	4370	10.4	26.7
"	120	2010	4310	10.6	26.2

TIME CONSTANT 24 Hrs 0.6% KCN.

	Assay at end Au	Assay at end Ag	Extraction % Au	Extraction % Ag	
100 mesh	2141	5360	6.12	10.00	Plain
"	2005	5100	10.80	14.4	PbO
"	2075	5300	9.00	11.00	Pb Ac

In each of these experiments 100 gm of ore was used, with 400 c.c. of solution.

It is a fact that the solubility of gold and silver in KCN is different, even though the same conditions of treatment prevail. It should be borne in mind that there is generally a greater bulk of silver than of gold, which would materially increase the time necessary for solution.

With these facts in view, three silver minerals of considerable richness, although more or less impure, were procured.

(1) Ore No 2 is a cerargyrite, relatively low in silver, carrying some lead, also some copper and a little pyrite.

(2) Ore No 3 is a Pyrargyrite, high in silver, contains a small amount of arsenic, sulphur, and antimony. It also contained about 0.5% of copper, probably as chalcopyrite.

(3) Ore No 4 is supposedly argentite, very rich in silver, about 2% of cobalt, probably in the form of smaltite; also a small amount of copper.

A preliminary test on the raw ores demonstrated the best strength of cyanide was 0.6%, and that the best size for crushing was 100 mesh.

Table 5

EXPERIMENTS ON RAW ORE
Time 50 hours- 1.2% KCN.

	CaO lbs/ton	Assay start	Assay end	% extraction	KCN
1 Cerargyrite	1.25	445	190	57.2	0.82
2 Pyrargyrite	0.40	9770	9780	10.1	0.99
3 Argentite	1.00	18160	15905	13.4	0.82

CHLORIDIZING ROAST-AIR AGITATION- 1.2% KCN

Strength kept constant. 50 hours time.

4 Argentite	1.00	12110	2580	91.2	
5 Pyrargyrite	0.40	5130	450	78.7	

CHLORIDIZED ROAST. NO AGITATION. 0.6% KCN
Time 50 hours,

6 Argentite	1.00	17400	820	95.2	0.454
7 Pyrargyrite	0.40	9000	1850	79.5	0.320

SULPHATIZED ROAST 1.2% KCN.
Time 50 hours,

8 Argentite	1.00	18850	12900	31.6	0.632
9 Pyrargyrite	0.40	9050	7680	12.3	0.785

RAW ORES. Varying conditions, sol constant
0.6% KCN, Time 75 hours.

					Extras
10 Pyrargyrite	0.40	9770	6010	38.40	40 c.c. sol
11 "	0.40	9770	7760	20.60	300 c.c. sol
12 "	0.40	9770	7840	19.70	200 c.c. 5% Bromine water
13 "	0.40	9770	8450	13.50	300mg Pb Ac
14 "	0.40	9770	7000	28.60	300mg Hg Cl2
15 "	0.40	9770	4860	13.50	300mg PbO
16 Argentite	1.00	15905	9870	38.00	Heat

Experiment No 1,Table 3,shows the extreme solubility of silver in the chloride form.No's 2 and 3 were raw ores,the low extraction on which indicates their inadaptability to plain cyanidation.

Numbers 4,5,6,and 7 were subjected to a chloridizing roast, 10% of salt being used.The ore was weighed and assayed,both before and after roast,and the per cent loss calculated as shewn in Table 4 below.

Table 4.

	Assay Plain	Total Ag.	Assay roast	Ag at end	Loss	%
Pyrargyrite	9770	489500	9000	450000	38500	7.9
Argentite	18100	906000	17400	880000	28000	3.09

The loss due to volatilization will depend upon many factors, briefly covered by the character of the ore and manner of treatment.Hoffman has succeded in holding his losses of silver due to volatilization,on argentiferous lead and zinc ores as low as 1.3%,a fair average being 7.9%

If the ore is simply argentiferous,carrying no gold,it is doubtful as to whether a chloridizing roast,with subsequent cyanidation is economical,as in this case,cyanide would enter into competition with sodium hyposulphite.

In cases of an ore such as Ore No 1,cyanide in conjunction with a chloridizing roast,would prove equally effective on both gold and silver,the question as to losses and comparative cost with other processes being the governing factor.

The high percentage of extraction shown in No's 6and 7 was obtained without either aeration or agitation.

No 10 shows that a large ratio of solution to ore is beneficial -here the ratio of ore to solution was 1 to 8

Bromine was used in Exper 12 with no especial advantage shown

No 14 confirms to some extent the suggestion that $HgCl_2$ is beneficial to good extraction,and especially so when compared with PbO and Pb Acetate,which seem to retard rather than hasten the solution of silver.

In No 15,we have an example of an ore treated with 0.6% cyanide solution,and kept at a temperature of 80 degrees C, which argues strongly in favour of heated solutions.

In all the experiments in Table 3,except otherwise specified, 50 grammes of ore were used and 200 c.c.of solution.

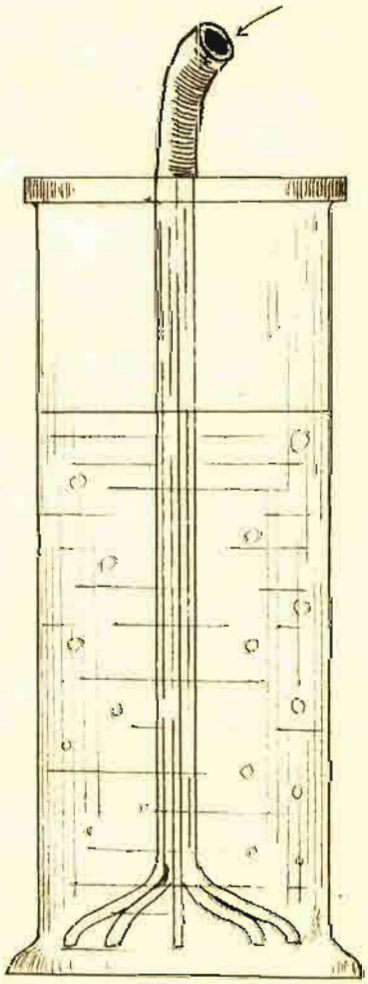
The lack of time made it impossible to investigate the effects of a sulphatizing roast on the sulphuretted ores,Pyrargyrite and Argentite further than as shown in Nos.6and 9.

The cobalt contained in the Argentite,after a chloridizing roast,seemed to have no injurious effects,but just what effect it has upon the sulphatized material,must be determined by additional experiment.

The low extraction obtained on the Pyargyrite,Experiment No 9, can probably be attributed to an incomplete sulphatizing roast as the per centage of sulphur in this ore was low.

The apparatus consisted of a number of anatomical jars, three inches in diameter, and eighteen inches in height.

Various methods were tried in order to obtain a thorough circulation of both ore and solution, most of these proving unsatisfactory. Eventually it was found that the best aeration and agitation could be obtained by having a number of air pipes radiating from one main supply pipe, as shown in sketch below. In this way effectual aeration and agitation was obtained, and the rate of extraction materially assisted.



Conclusions.

I. In the case of ore No 1,the gold being coarse,amalgamation prior to cyanidation would be the proper method of treatment, with the subsequent cyanidation of the tailings.As an alternative scheme,the ore might be subjected to a chlorodizing roast,followed by amalgamation and cyanidation.

II. Ore No 2 gives excellent results in the raw state,as shown by a test extending for 50 hours.With additional time,a comparatively complete extraction could be secured.

III. In treating ores 3 and 4,the marked advantage of a chlorodizing roast is obvious.As previously intimated,it is entirely a matter of dollars and cents,as to whether the subsequent treatment shall be by lixiviation with sodium hyposulphite, or by cyanidation,as each of these processes gives high extraction of chlorodized ores.